

# WIRELESS BROADBAND INFRASTRUCTURE:

A CATALYST FOR GDP AND JOB GROWTH 2013-2017

Alan Pearce, Ph.D., J. Richard Carlson, MBA, Michael Pagano, Ph.D.

Prepared for PCIA – The Wireless Infrastructure Association  
*by* Information Age Economics

September 2013

## TABLE OF CONTENTS

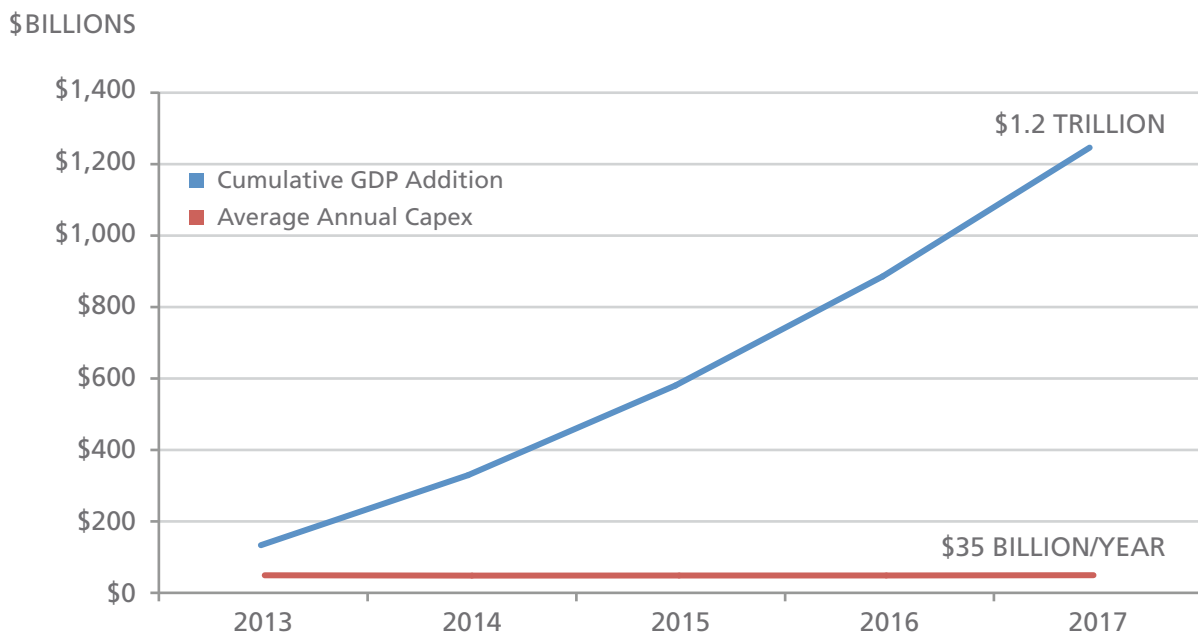
Executive Summary .....	1
Introduction .....	2
Background .....	3
Wireless Broadband Today .....	7
Economic Impact of Previous Enabling Technologies .....	8
Indirect Benefits of Widespread Deployment of Wireless Broadband Infrastructure .....	9
Machine-to-Machine Applications .....	9
Non-MTM Mobile Productivity Applications .....	12
Mobile Payments .....	13
Mobile Entertainment .....	14
Economic Model and Discussion .....	17
The Keynesian Effect .....	17
Innovation and Network Effects .....	19
The Summed Effect .....	22
The Impact on Employment .....	24
Conclusions .....	27
References .....	28
The Research Team .....	29
Appendices .....	30

## EXECUTIVE SUMMARY

Politicians, policy makers, business leaders, the mass media, and the American people are focused on key sectors of the nation's economy that have the potential to yield significant and rapid increases in employment and Gross Domestic Product (GDP). Leading the pack is the wireless broadband infrastructure sector of the telecommunications-information-entertainment (T-I-E) industry that, as this report demonstrates, can deliver both of these major economic benefits at relatively low cost. The infrastructure that enables wireless broadband represents a vital and sustaining technology capable of rapidly creating jobs, applications, and technologies that will maintain the nation's global technological, political, and economic-business leadership.

This research report by Information Age Economics (IAE) estimates that industry projected mobile broadband investments of between \$34-36 billion per year will increase GDP in 2017 by 1.6% to 2.2% (\$259.1 to \$355.3 billion in dollar terms) and generate up to 1.3 million net new jobs, *i.e.*, even after accounting for potential job losses due to increased productivity, outsourcing, *etc.*<sup>1</sup> Importantly, over 28,000 of these jobs are directly attributable to the investment in the build-out of wireless broadband. This significant increase in GDP, due to continued private investment in wireless broadband networks, is achievable because of an anticipated surge in mobile-based technological innovations and applications, as well as the conventional direct and indirect effects of these additional capital expenditures (capex).

## WIRELESS INFRASTRUCTURE IMPACT ON GDP (IN BILLIONS)



<sup>1</sup>The introduction of disruptive technologies frequently leads to isolated and concentrated job losses within certain sectors, even though jobs in the aggregate increase due to the economic value resulting from the new technology. For example, the advent of the automobile created numerous jobs in the manufacturing and service industries while reducing demand for stage coach manufacturing and horse groomers. This study accounts for both effects.

Investing in wireless broadband access infrastructure almost immediately stimulates job and income growth, due to sizable “direct” investment in wireless facilities and expanding network capacity as the industry continues to build-out 3G and 4G systems to every corner of the country. IAE estimates this expansion will add \$85 billion to \$87 billion of economic growth per year in *direct* benefits alone. This significant impact is noteworthy by itself, but investment in wireless broadband infrastructure will also have an “impact catalyst” effect, stimulating more powerful and positive *indirect* network benefits by deploying and providing available wireless broadband services to all areas of the U.S. These *indirect* network benefits, offering improved wireless broadband access and higher data speeds, will lead to a plethora of new business formation, while existing businesses and organizations will reap sizable gains in efficiency as they identify new sources of revenue by obtaining and exploiting access to machine-to-machine (M2M), mobile payment, and other productivity-enhancing applications and services. Indeed, the indirect impacts will be add between 1.42% on the low end and 1.69% on the high end in GDP, representing a range of \$225 billion and \$268 billion of increased economic activity.

In the same vein, consumers will benefit from efficiencies in searching for and buying goods and services, along with information and entertainment content delivered to their mobile devices anywhere at any time. Additionally, consumers will enjoy innovative new forms of entertainment that were not viable, or imaginable, prior to the advent of wireless high-speed networks.

Investment in wireless broadband acts as a catalyst to significant economic growth because the direct investments are sizable by themselves while additional network advances create the highway for larger and more profound positive socio-economic effects. As an industry, wireless infrastructure “punches well above its weight” due to its outsized positive effects upon the economy and will be a key ingredient to economic and job growth in the United States for the foreseeable future.

## I. INTRODUCTION

Wireless broadband, currently defined as 3G or better, is available to an estimated 99.5% of the U.S. population en route for a planned 100%.<sup>2</sup> This report confirms the conclusion by other studies that wireless broadband is not only a globally popular technology, it is now an indispensable and critical part of the fabric of a modern, growing global economy. Indeed, wireless broadband is such an important enabling technology that it is likely to unleash positive productivity shocks from derivative innovations and is therefore akin to other disruptive enabling technologies, such as the deployment of the electric infrastructure, the national railroad and interstate highway systems, the invention of the combustion engine, the global impact of the personal computer, as well as the Internet and the World Wide Web, in its outsized contributions to economic growth and employment. As Gordon (1999, 2012) points out, major innovations create “first order” effects that are greater in magnitude than evolutionary products,

<sup>2</sup> Implementation of Section 6002(b) of the Omnibus Budget Reconciliation Act of 1993; Annual Report and Analysis of Competitive Market Conditions With Respect to Mobile Wireless, Including Commercial Mobile Services, WT Docket No. 09-66, *Fourteenth Report*, 25 FCC Rcd 11407, 11487–88, ¶ 122 (2010); Implementation of Section 6002(b) of the Omnibus Budget Reconciliation Act of 1993; Annual Report and Analysis of Competitive Market Conditions With Respect to Mobile Wireless, Including Commercial Mobile Services, WT Docket No. 11-186, *Sixteenth Report*, 28 FCC Rcd 3700, 3834, Table 32 (2013).

such as the VCR and hybrid cars, due to the sizable indirect benefits from such innovations.<sup>3</sup> The study quantifies the impact of this change on GDP and job growth, using referencing data from previous eras as well as a top down and bottom up market analysis. Specifically, this report calculates the direct impact of wireless broadband on the U.S. economy by employing a traditional Keynesian analysis. Explicitly, it estimates the direct impact on GDP and employment stemming from additional investment in wireless broadband, as the wireless infrastructure sector continues to add sites, increase coverage, and provide high speed services and applications on a near-universal and ubiquitous basis.

Additionally and importantly, the report examines and quantifies the projected economic impact of wireless broadband as an enabling technology in the U.S. Now that wireless broadband is becoming truly ubiquitous and its competing systems and infrastructures have reached a “critical mass,” it can provide a foundation for a wave of investment in M2M applications, mobile payment systems and marketplaces, an increasing array of imaginative and innovative applications, and “smart” devices that completely un-tether white and blue collar workers from their desks and vehicles, while spurring a plethora of new entertainment and information options. The indirect effects from technologies that enable other technologies are therefore larger and more profound than the early direct and more obvious impacts.

As an exciting enabling technology, the direct and indirect benefits of wireless broadband will unleash a positive “productivity shock,” increasing employee productivity and corporate profits, as well as driving GDP growth, which will then circle back into more hiring and employment gains. The primary objective of this research report is to quantify the economic impact that wireless broadband infrastructure will have on the U.S. economy over the next five years, stemming from both the direct and indirect benefits of this critical technology.

## II. BACKGROUND

Given the rapid and somewhat unexpected proliferation of wireless services since they were commercially launched in October 1983, there are now data to support the hypothesis that we are witnessing major positive economic effects stemming from the deployment of broadband wireless, not just in the U.S. but also in many parts of the world. There is a growing body of literature that attempts to quantify the economic effects and societal impacts.

Katz (2012) provides a current and comprehensive survey of these studies and finds that investments in broadband infrastructure have had a positive, significant impact on economic growth, although, to date, the effect can vary widely. For example, numerous studies noted in Katz demonstrate that a 10% increase in the penetration rate of broadband can increase GDP by between 0.25% and 1.38%.<sup>4</sup> Katz attributes the positive effect on GDP to three

<sup>3</sup> As one of the world’s leading experts in the area of productivity and economic growth, Professor Robert J. Gordon identifies in recent work (1999, 2012) four clusters of major inventions that occurred during the late 19th century and first half of the 20th century, namely, “electricity (including electric motors, the electric light, and consumer appliances), internal-combustion engines (motor transport, air transport, superhighways, super-markets, and suburbs), ‘rearranging molecules’ (petrochemicals, plastics, and pharmaceuticals), and communications/entertainment (telephone, radio, movies, and television).” As these technologies became widespread, U.S. productivity surged to its highest levels during the post-World War II period (1950-1972).

<sup>4</sup> See Katz, R.L. (2012). See also INTERNATIONAL TELECOMMUNICATION UNION, IMPACT OF BROADBAND ON THE ECONOMY (2012), [http://www.itu.int/ITU-D/treg/broadband/ITU-BB-Reports\\_Impact-of-Broadband-on-the-Economy.pdf](http://www.itu.int/ITU-D/treg/broadband/ITU-BB-Reports_Impact-of-Broadband-on-the-Economy.pdf).

primary benefits that broadband provides: 1.) Productivity improvements due to more efficient business processes, e.g., managing inventory and supply chains; 2.) New consumer applications and services; and 3.) More effective organizational structures, e.g., virtual call centers, outsourcing, telecommuting.

In analyzing the influence of broadband on employment, Katz and Suter (2009) used a “bottom-up” approach to decompose the overall economic impact into *direct*, *indirect*, *induced*, and “*network*” effects. Direct effects are jobs generated due to direct investment in broadband infrastructure, e.g., construction of cell towers, network systems, *etc.*, while indirect effects are job gains associated with businesses that are down-stream and up-stream of the broadband network, e.g., communication equipment suppliers, commodity producers, *etc.* Induced effects on employment are the jobs created because of the additional personal income generated by the direct and indirect effects noted above. For example, induced jobs could be created because the employees of a cell tower construction company use their additional income to purchase more goods and services in the local economy, thus causing restaurants, car dealers, consumer retailers, *etc.*, to hire more workers. These three effects (direct, indirect, and induced) are considered to be the key elements of a traditional Keynesian analysis of economic impact.<sup>5</sup>

As discussed in greater detail below, a fourth effect (above and beyond the typical Keynesian effects) has grown in importance, namely, the role that broadband can play as an “economic network” that accelerates business innovation.

Furthermore, Martinez, Rodriguez, and Torres (2010) demonstrate that improvements in information and communication technology (ICT) can have a large impact on the overall economy, as changes in ICT accounted for approximately 35% of total growth in U.S. labor productivity during 1980-2004. Katz (2012) and Crandall, Lehr, and Litan (2007) observe that broadband has a stronger impact on specific “information-intensive” sub-sectors of the economy, such as education, health care, financial services, and manufacturing. More broadly, Evans and Annunziata (2012) assert in a report sponsored by General Electric that wireless broadband, coupled with data gathered from wireless “smart devices,” will help create a new surge in productivity as an Internet of Things (IoT) becomes feasible over the next decade. As we outline in a later section, wireless broadband can serve as the enabling technology that permits businesses to create an “Industrial Internet” where M2M communications and other mobile-based services spur greater innovation and economic efficiency.<sup>6</sup>

Another important aspect of rapid broadband deployment to consider is that it can take time for businesses and consumers to learn how to best utilize the new communication technology. Katz (2012) notes that organizations need time to re-design their business processes and structures so that they can “accumulate intangible capital” that enables them to take advantage of this new technology. This, in turn, creates a delay between the roll-out of a new technology and its ultimate impact on economic growth, employment, and productivity. Jorgenson (2001) asserts that investments in information technology (including computers as well as communication equipment) can generate a large portion of the gains in productivity and economic growth while there is usually a time lag between a technology’s introduction and the realization of these gains. Numerous studies of technological change support this

<sup>5</sup> In addition to Katz and Suter (2009), Pearce and Pagano (2009), Crandall, Jackson, and Singer (2003), and numerous other studies employ this Keynesian type of economic analysis.

<sup>6</sup> PETER C. EVANS & MARCO ANNUNZIATA, GENERAL ELECTRIC, INDUSTRIAL INTERNET: PUSHING THE BOUNDARIES OF MINDS AND MACHINES (Nov. 26, 2012), [http://www.ge.com/sites/default/files/Industrial\\_Internet.pdf](http://www.ge.com/sites/default/files/Industrial_Internet.pdf).



notion of a delayed effect, not only in the U.S. but also around the world. For example, Gordon (1999, 2012) notes that the full impact of major inventions, introduced during 1870-1940, was not felt in the U.S. until 1950-1972. Crafts (2004) found a similar effect for technological change on British productivity and GDP growth during the Industrial Revolution period of 1780-1860. Further, Prados de la Escosura and Roses (2009) document that Spain's introduction of railroads, during 1850-1883, and electrification, during 1920-1929, ultimately led to significant increases in growth and productivity during the "Golden Age" of 1950-1974, as these earlier inventions became widespread.

These economic phenomena suggest that a "critical mass" is required before a technological change can have a meaningful and lasting impact on a nation's growth and efficiency. Consistent with these lessons from economic and business history, Roeller and Waverman (2001), Fornefeld, Delaunay, and Elixmann (2008), Koutoumporis (2009), and Katz (2012) all demonstrate that this critical mass (or "threshold") effect is also observed in the telecommunications industry. For example, Roeller and Waverman (2001) show that "near universal" service penetration was required for fixed telephony to ultimately have a significant impact on economic growth. These points are particularly relevant in the case of wireless broadband where many business participants often will not rely on a new technology like wireless until network coverage is almost everywhere they need it.

The econometric analysis of Koutoumporis (2009) provides statistically robust and reliable estimates of the impact of broadband on growth in 22 OECD (Organization for Economic Co-operation and Development) countries and demonstrates that a critical mass point exists (at around a 30% penetration rate as of 2006). The author discovered that nations with higher penetration rates enjoyed faster GDP growth than nations with low broadband penetration. This nonlinear relationship between penetration rates and economic growth identifies inflection points at penetration rates of 20% and 30%. Koutoumporis (2009) demonstrated that nations with penetration rates below 20% received the least benefit from broadband, while countries between 20% and 30% experience more growth (but not as much as nations with penetration rates above 30%). Thus, moving from a "moderate" 20%-30% level to the "high" penetration rate is both statistically and economically meaningful. For example, the U.S. was classified as a "medium penetration" country, and thus was included as a country where broadband had an average impact on U.S. GDP growth during the study period (2002-2007) when GDP growth was equivalent to a lackluster 0.20% per year. However, "high penetration" countries, such as Switzerland and Denmark, reported an annual impact twice as large as that of the U.S., e.g., 0.37% to 0.41%. This empirical finding suggests that the impact of broadband on U.S. growth can be enhanced as penetration increases, i.e., availability and affordability, closer to 100%.

Consistent with Koutoumporis (2009), Fornefeld, *et al.*, (2008), reports that broadband also has a nonlinear effect on growth and productivity in the European Union (EU). As in Koutoumporis (2009), the economic impact of broadband in Europe is positively related to the penetration rate of this service, with stronger effects observed for nations that use broadband more pervasively. The study also finds that innovation related to business processes and services is "crucial for the development of new markets and economic growth in developed countries" which, in turn, can generate increased employment in knowledge-intensive activities, even after accounting for jobs displaced due to outsourcing and office automation (in economic terms, this is referred to as the substitution of costly labor with inexpensive capital). The authors estimate the "base" ratio between jobs-gained-to-jobs-lost to be 1.12, and

ranges from a low of 0.96 (indicating some slight net job losses) to a high of 1.26. While these innovations result in net positive jobs, policy makers would be wise to provide job training and other solutions to ease these transition for certain workers.

In addition to Fornefeld, *et al.* (2008), Czernich, *et al.* (2009), Katz and Suter (2008), and Shideler, *et al.* (2007), observe that the deployment of broadband can have an insignificant, or even negative, effect on employment once the service has reached a saturation point. That is, once broadband has reached a sufficiently high penetration rate, the impact of further broadband proliferation on job growth can, in theory, be negative. These studies cite factors similar to those noted in Fornefeld, *et al.* (2008), such as outsourcing, improved business processes, and the substitution of cheaper capital for more expensive labor, especially in labor-intensive industries. In order to offset these negative effects on job growth, many of these researchers suggest that the impact of broadband deployment on business innovation is the key solution. As noted earlier, Katz and Suter (2009) estimate “network” effects on employment that are *not* due to the more conventional Keynesian factors, such as the direct, indirect, and induced effects on employment.

Katz and Suter (2009) describe how broadband-initiated innovation can increase jobs through either: 1) new business services, *e.g.*, new types of firms can be created, such as mobile entertainment services; and 2) new economic activity, *i.e.*, additional revenue generated for existing firms due to increased broadband access. The authors estimate that new businesses could have created 175,000 jobs by 2012 while new economic activity for existing firms could generate an additional 203,000 jobs. Thus, the total “innovation effect” of broadband on employment is 378,000 jobs and on a net basis can lead to as many as 273,000 new jobs (after accounting for potential job losses due to the effects of increased productivity and outsourcing). These innovation-related job gains are substantially higher than the “direct” effect on jobs due to building out the wireless broadband infrastructure. For example, Atkinson, Castro, and Ezell (2009) estimated that a \$10 billion stimulus program related to U.S. broadband services could yield 268,500 jobs above and beyond the program’s 64,000 “direct” jobs due to “network effects.” Thus, the impact of innovation on job growth can be *more than four times* the direct impact of broadband investment on employment.<sup>7</sup> Using earlier data, Fornefeld, *et al.* (2008), performed a similar analysis for Europe and found that broadband-initiated innovation in knowledge-intensive businesses can generate a net gain of 105,000 jobs during 2006.

The key to increasing employment, as well as spurring economic growth and productivity, is to leverage wireless broadband capacity as an enabling technology by facilitating innovation within existing firms and through the creation of new services and companies.

In sum, the impact of wireless broadband on economic growth, productivity, and employment is positive and the effect is non-linear in nature. The strongest effects occur once broadband penetration achieves a critical mass in terms of cost and accessibility. In addition, as wireless broadband approaches “universal coverage” in the U.S., the economic benefits of continued broadband investment will increasingly be due to innovation-related “network effects,” such as the creation of new businesses, as well as the development of new models/processes for existing firms.

<sup>7</sup> Katz and Suter (2009) refer to the ratio of innovation-related jobs to direct jobs as a “network effect” job multiplier and report that this multiplier can range from 0.07 to 7.28, with a mid-point estimate of 3.65 (which is quite close to Atkinson *et al.* estimate of 4.20).



### III. WIRELESS BROADBAND TODAY

Wireless communications has been one of the most successful business and consumer services in economic and business history. From its inception in the early 1980s when analysts wondered whether there would ever be more than 2 million subscribers, wireless has grown to the position that there are now more subscriptions than people in the United States, with more growth forthcoming in the near future due to the high value that wireless broadband provides. There are an estimated 340 million wireless subscribers in the U.S. today and 81% or 256 million are already using 3G systems or mobile broadband, according to Informa WCIS.<sup>8</sup> Recent estimates indicate that 99.5% of the population has access to wireless broadband and that percentage is growing.<sup>9</sup> Over the next five years, nearly all the remaining subscribers will be converted to 3G and faster networks as they trade out “old” subscriber devices and upgrade to the faster services via 3G and 4G smartphones. In addition, new subscriptions will also increase due to more subscriptions per household, and more data consumption, including those from M2M applications.

Data represents the fastest revenue category for broadband wireless operators and now has breached over 50% of overall service revenues, growing by double digits for most of the last decade. While email and light web browsing spurred data growth early in the last decade, growth is now driven largely by the widespread adoption of “smartphones” and tablets used by both consumers and businesses alike, and the applications that run on those devices. According to Gartner, 2013 will be the year that smartphones and tablets surpass 1 billion global users, with an estimated 40% in the U.S. alone.<sup>10</sup> Gartner expects business use of tablets to triple as enterprises move more functionality out to those devices.<sup>11</sup> Demand for smartphones is booming, and, perhaps symbolically, 2012 was the first year that smartphone sales beat PC sales in unit sales.<sup>12</sup>

To capture this opportunity, wireless operators are encouraging infrastructure providers to increase the aggregate number of cell sites and to increase wireless communications’ share of overall T-I-E industry spending by rolling out small cell solutions, including microcells and femtocells, along with other infrastructure developments and technologies, so that consumers and businesses have access to wireless broadband, no matter where they are. Wireless broadband availability is not only increasing by covering more of the population in rural and remote areas, infrastructure providers are “laying the rails” inside buildings, underground in metros, on university and corporate campuses, in stadiums, retail outlets, and even on airplanes. In short, access is provided wherever people or machines are located and/or congregate. To quantify this, the number of microcells is projected to grow from 2.5 million to 54.5 million sites over the next five years, according to recent data from Infonetics.<sup>13</sup> Service providers are getting a jump on deploying 4G networks in order to serve consumers’ increasing appetite for mobile video along with a plethora of other imaginative services. Penetration of 4G is projected to grow

<sup>8</sup> *Global Mobile Statistics 2012 Part B: Mobile Web; Mobile Broadband Penetration; 3G/4G Subscribers and Networks*, MOBITHINKING (Dec. 2012), <http://mobithinking.com/mobile-marketing-tools/latest-mobile-stats/b>.

<sup>9</sup> FCC, *CONNECTING AMERICA: THE NATIONAL BROADBAND PLAN*, GN Docket No. 09-51 (2010), <http://www.broadband.gov/plan/>.

<sup>10</sup> Natasha Lomas, *Gartner: 1.2 Billion Smartphones, Tablets to be Bought Worldwide in 2013*, TECHCRUNCH (Nov. 6, 2012), <http://techcrunch.com/2012/11/06/gartner-1-2-billion-smartphones-tablets-to-be-bought-worldwide-in-2013-821-million-this-year-70-of-total-device-sales/>.

<sup>11</sup> *Ibid.*

<sup>12</sup> Henry Blodgett et al., *The Future of Digital*, BUSINESS INSIDER (Nov. 27, 2012), <http://www.businessinsider.com/future-of-digital-slides-2012-11?op=1>.

<sup>13</sup> INFONETICS RESEARCH, *FEMTOCELL EQUIPMENT REPORT* (March 2013).

from approximately 7% at the end of 2012 to nearly 50% by the end of 2017, according to a recent Jefferies and Company report.<sup>14</sup>

The growth of wireless broadband networks is also attracting a wave of investment, as evidenced by mobile venture capital support, reaching a record level in 2012. Private companies raised \$6.9 billion in venture capital through 990 deals in 2012, as compared to \$6.3 billion and 791 deals in 2011, and \$4.5 billion and 417 deals in 2010.<sup>15</sup> Mobile-related firms also obtained an estimated 40% of all venture capital investment in 2012, up from 12.9% in 2001.<sup>16</sup> The leading investment themes were mobile consumer applications, mobile commerce and payments, enterprise mobile, mobile marketing and advertising, and mHealth companies.<sup>17</sup> The rate of investment is increasing as adoption and introduction of new services and the build-out of wireless infrastructure go hand-and-hand. In other words, as the networks surpass a critical mass of population and geographic coverage, innovators can build upon them, trusting that users will have ubiquitous and universal access to the products and services developed by the innovators.

To summarize, the wireless sector of the T-I-E industry has moved from a mobile phone sector, driven by increased voice usage, to a business sector that will play a critical role in future economic and job growth by enabling additional technological breakthroughs riding on the wireless broadband infrastructure. According to Sandage (2012), the Internet will make the final move from a primarily wired, desk-bound environment, to “a mostly mobile medium” during 2013, as KPCB and Morgan Stanley Research forecast that the global installed base of smartphones and tablet computers will outnumber desktop and notebook PCs for the first time. In just three years, an estimated 80% of Internet access will be on these smart and easily portable devices.<sup>18</sup>

## IV. ECONOMIC IMPACT OF PREVIOUS ENABLING TECHNOLOGIES

Through the lens of economic and business history, it can be documented that key innovations have had major, long-lasting effects on productivity, business and job growth once these innovations have become widely available, and businesses and consumers have learned how to use them to their full advantage. As noted, Gordon (2012) has identified three “industrial revolutions” referred to as “IR1” (roughly, 1750-1830), “IR2” (1870-1900), and “IR3” (1960-2000), in which to measure the impact of innovation on economic growth and productivity. He documents sharp increases in both productivity and economic growth in each of these eras which are bracketed by slower periods of activity.<sup>19</sup> This analysis is based on over a century of detailed economic data from 1891-2012 and examines effects of groundbreaking innovations, such as widespread use of railroads, the combustion engine, and electrification of homes/businesses. Using these data, we find that the ratio of GDP growth-to-productivity growth exceeds one (at 1.56x during this 1891-2012 period). Thus, a 1.08% surge in annual productivity, like that observed for the Internet’s proliferation, e.g., 1996-2012, can translate into a 1.68% acceleration in annual economic growth.

<sup>14</sup> Jefferies & Company, *4G Mobile Wireless Penetration in North America from 2011 to 2020 (in percent)*, STATISTA (Sept. 2010), <http://www.statista.com/statistics/232674/4g-mobile-wireless-penetration-in-northern-america/>.

<sup>15</sup> Rutberg & Co., LLC, *Wireless Industry Newsletter* (Dec. 2012).

<sup>16</sup> Ibid.

<sup>17</sup> Ibid.

<sup>18</sup> Henry Blodgett et al., *The Future of Digital*, BUSINESS INSIDER (Nov. 27, 2012), <http://www.businessinsider.com/future-of-digital-slides-2012-11?op=1>.

<sup>19</sup> In Gordon (1999), the author refers to this pattern as “one big wave” which starts slowly in 1870, rises to a peak during 1950-1972, and then decelerates for the remainder of the 20<sup>th</sup> century.

Other research by Jorgenson (2001), which focuses on the post-World War II period of 1948-1999 in the U.S., confirms a pattern similar to the one documented by Gordon (1999, 2012). In addition, Jorgenson (2001) finds that a major contributor to the surge in productivity during this period has been investment in “ICT” equipment (information and communication technology). In parallel, researchers such as Crafts (2004), Prados de la Escosura and Roses (2009), and Katz (2012) have found similar surges in productivity in countries such as Britain, Spain, and emerging markets. Overall, these studies demonstrate that ICT investment can be a key catalyst to spark productivity gains that, in turn, translates into a substantial acceleration of economic and job growth. This pattern is not unique to the U.S., as the impact of ICT investment appears to have a universally positive effect on productivity and economic growth around the world.

## V. INDIRECT BENEFITS OF WIDESPREAD DEPLOYMENT OF WIRELESS BROADBAND INFRASTRUCTURE

We now turn to and describe the economic impact of several new technologies that have been made possible now that wireless broadband is surpassing a critical threshold of availability. Innovators and users of these technologies are reaching the point where they can move forward with their business plans with the knowledge that the underlying infrastructure will be there to serve them. Each of these technologies benefits from the pervasiveness of the network. IAE will first describe the technology and its use, then present forecast data, and finally estimate the economic impact over the next five years.

### A. MACHINE-TO-MACHINE APPLICATIONS

M2M technology can be defined as the connection between one source of data that automatically (without human intervention) sends such data over a network (frequently wireless) to another device or computer, which then takes the data and manipulates it, or packages it, into a form where human decision-makers can analyze the results in order to make decisions and/or change a process. Oil and gas companies, for many years, have had sensors and devices on pipelines to measure flow data in order to make sure such pipelines do not have leaks or blockages, as well as to calculate volumes and revenues. Fleet operators are increasingly implementing solutions that take data from service trucks to calculate fuel usage, driver location, truck speed, and, sometimes, vehicle performance data. This data is sent wirelessly from devices installed on the vehicle and then put through software systems that take it, combine it with other information, and package it in ways for various supervisors and dispatchers to use to make decisions. For example, supervisors can determine whether a cable technician will get to her/his next install on time or whether a beverage delivery person is being unduly hard on his/her vehicle through rapid starts and stops, or even whether it is time to bring the vehicle in for service, all without human intervention. Commercial espresso machines are now being manufactured to “call out” to service providers when performance drops into preset levels before they break down to the delight of retailers who rely upon such machines. GPS driven tractors are now fertilizing fields, saving farmers time and money by covering their fields more accurately and without overlap (think of mowing a lawn and how often you retrace) and dispatching the precise levels of fertilizer needed for the terrain. Consumers taking a weekend away from home can remotely turn the heat on in their mountain retreat so that it is

warm as soon as the family arrives. Some prognosticators even forecast linked sensors working together in systems to make our lives easier without any human intervention at all. Simple examples would be alarm clocks that automatically start coffee pots, moisture sensors that activate sprinkler systems, and thermostats that are triggered by motion sensors.<sup>20</sup> More complex examples could be a series of personalized appliances and devices that remain dormant when you are not home yet activate as soon as you enter your dwelling.<sup>21</sup> These are just a few of the examples of the M2M applications that are beginning to impact the economy and promise to usher in sizable productivity gains over the next several years.

There are a multitude of factors that have created the climate for innovators to develop M2M applications. Most importantly, sensors and devices that capture such data have plummeted in price thus opening up the market to new applications that were previously cost prohibitive. For example, the price of GPS devices containing wireless modems that are installed in service vehicles which used to cost more than \$500 five years ago, can now be purchased for less than \$100, with more functionality and more data processing power. Another factor is software that can manage and manipulate such data can now be developed much less expensively due to open source and other innovations, including access to cloud based infrastructures that allow providers to offer services on a subscription basis for as little as a few dollars per device per month. Concurrent with software development advances has been the rise of data analytical tools, aptly called “Big Data”, which enable machines to process increasingly large quantities of real-time data from sensors and networks. These systems and techniques enable application providers to offer customers fairly rigorous data analysis on a near real-time basis. Additionally, a new breed of enabling technology providers, including mobile virtual network operators (MVNOs), mobile virtual network enablers (MVNEs), and platform-as-a-service (PaaS) providers, are shortening the time-to-market and costs of market entry. Finally, open source software is giving developers an important boost to spur innovation. Qualcomm, one of the leaders in wireless broadband, recently introduced “Alljoyn,” an open source platform that enables disparate devices and sensors to communicate with each other.<sup>22</sup>

While some M2M applications have been around for over twenty years, the major breakthroughs will take place over the next several years, now that wireless broadband is passing a threshold where nearly all users will have access in one form or another, *e.g.*, home, office, factory, school, library, *et al.*, to broadband infrastructure. To illustrate this point, consider some of the new mHealth services. Individuals with chronic heart conditions can now wear devices that constantly monitor their heart rate and other critical health data. Should the heart rate range outside of pre-set parameters, the devices are programmed to send an alert wirelessly to a central point where a nurse can examine the data and, if need be, call the patient or dispatch emergency help. This solution, which replaced nurses making weekly visits, has simultaneously elevated care and leveraged the productivity of the nurses on staff, can only work once wireless broadband coverage is truly ubiquitous, available, and affordable. Clearly, someone with a chronic heart condition does not want to be given a coverage map of where he/she can go, or not go at her or his peril!

<sup>20</sup> Bill Wasik, *Welcome to the Programmable World*, WIRED (May 13, 2013), <http://www.wired.com/gadgetlab/2013/05/internet-of-things/all/>.

<sup>21</sup> Ibid.

<sup>22</sup> See [www.alljoyn.org](http://www.alljoyn.org) for a description of the software features and list of community members.

Similarly, while the stakes are not life or death, many business-to-business solutions make sense to deploy *only* when the underlying networks are available nearly all the time, otherwise the business will be forced to implement separate tools and processes for out-of-coverage situations. Using the cable technician example, without accurate location data, a cable company cannot respond to customers' inquiries about the status of an install if they themselves have incomplete data on the locations of their installer team. Moreover, businesses are reluctant to employ solutions that work only some of the time, or only on subsets of employees. The pervasiveness of the wireless broadband infrastructure gives economic actors the incentive to innovate and deploy the technologies riding on it, once the infrastructure passes a critical mass threshold, in the same way that automobile travel in rural areas made practical sense when there were an adequate number of gas stations. This automobile business scenario must be repeated in order for electric powered vehicles to reach a mass, nationwide market.

The agricultural, forestry, construction, and mining industries are being overhauled as equipment providers such as John Deere, Trimble, Caterpillar, Case New Holland and others help farmers manage inputs, increase productivity, and reduce costs by combining equipment, data analysis, and wireless broadband technologies. Deere presents case study data indicating that one Indiana farm was able to save over \$180,000 a year in operating costs, while adding over \$1 million in revenue, due to more accurate seeding from machines being controlled through M2M solutions.<sup>23</sup> The key to more farmers enjoying results like these will be further network expansions that close the coverage gaps, as well as increased adoption of these M2M solutions.

No matter how one measures it, M2M solutions are growing rapidly, and implementation of such solutions is projected to grow robustly over the next several years. The latest projections for M2M communications show that worldwide device connections will grow by a factor of 20 in the next ten years, and climb from approximately 100 million to 2.1 billion, according to a recent report by Analysys Mason.<sup>24</sup> The revenue associated with M2M connectivity will also increase dramatically and reach \$50.9 billion by 2021, according to the same study.<sup>25</sup> The study foresees M2M connections growing at compound annual rates of 32%, from an estimated 22.6 million in 2011 to a forecast of 429 million by 2021, with nearly all connections on wireless networks.<sup>26</sup> Cisco recently released a forecast that M2M traffic will grow 24-times between 2012 and 2017. Cisco asserts that M2M traffic will account for 5% of total mobile data traffic in 2016, and that the number of M2M modules is expected grow 4.6 fold to 1.7 billion by 2017.<sup>27</sup> ABI Research projects North American M2M wireless connections to grow from an estimated 29.55 million in 2011 to 100.82 million in 2016.<sup>28</sup> The analysts believe that growth will come primarily from the U.S. and other developed nations initially, but that emerging markets will follow suit very quickly, and are more likely to go directly to wireless connected solutions.

<sup>23</sup> See Mark Lewellen, Manager Spectrum Advocacy, John Deere, Presentation, *Growing Rural American by Planting the Seeds of Wireless Broadband* at the PCIA Capitol Hill Event (Jul. 23, 2013), <https://www.youtube.com/watch?v=7nihgFac6cQ>.

<sup>24</sup> *20 Fold Increase Expected for M2M Device Connections*, BILLING & OSS WORLD (June 18, 2012), <http://www.billingworld.com/news/2012/06/twenty-fold-increase-expected-for-m2m-devices-con.aspx>.

<sup>25</sup> Ibid.

<sup>26</sup> Ibid.

<sup>27</sup> See CISCO, VISUAL NETWORKING INDEX: GLOBAL MOBILE DATA TRAFFIC FORECAST UPDATE, 2012–2017 (Feb. 6, 2013), [http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white\\_paper\\_c11-520862.pdf](http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-520862.pdf).

<sup>28</sup> ABI RESEARCH, CELLULAR M2M CONNECTIVITY SERVICES, 33 (Dec. 30, 2011).

The entrepreneurial activity and the examples provided indicate that M2M technologies will have a profound impact on service industries, the medical profession, the energy sector, consumer electronics, the automobile/truck sector, housing and, indeed, nearly every sector of the economy. As GE asserts in its report titled “Industrial Internet: Pushing the Boundaries of Minds and Machines”, the new M2M technologies and connectivity options will impact a wide and diverse range of industries. “With better health outcomes at lower cost, substantial savings in fuel and energy, and better performing and longer-lived physical assets, the Industrial Internet will deliver new efficiency gains, accelerating productivity growth the way that the Industrial Revolution and the Internet Revolution did.”<sup>29</sup> GE forecasts productivity increasing by 1.0 to 1.5% over the next 20 years, and average incomes increasing by 25% to 40% over the same period.<sup>30</sup> GE sees at least 50% of the global economy impacted by these new technologies that ultimately will run predominately on wireless broadband networks.

## B. NON-M2M MOBILE PRODUCTIVITY APPLICATIONS

Now that Wireless Broadband Infrastructure has almost become ubiquitous, enterprises and consumers are embracing an increasing array of applications that un-tether both segments from their desktops. In the office, these applications are enabling the following:

- Workers can work wherever they desire on a campus, once they arrive at work.
- Telecommuting is becoming much easier and acceptable, providing workers and their employers more time by reducing/eliminating commute time.
- Business travelers will be able to access mobile broadband on airplanes.
- Collaboration is easier, efficient and effective due to mobile broadband reducing the need for business travel.
- Video conferencing has moved to the device, further reducing the need for business travel and the expense of hotels.
- Nearly all workers will have access to company data and applications from customer sites.
- Customers and supply chain participants will be able to view their data outside the office.

The more forward-leaning businesses are also moving more and more of their data to cloud-based infrastructures and applications in order to facilitate the use of such information by and from “remote” workers. In addition, many organizations are moving toward open device policies, named BYOD (bring your own device), so that traveling and remote knowledge and other workers can access what they need on their device of choice. These policies help companies leverage the rapid adoption of smartphones and tablets while making IT’s life simpler on one hand, since they no longer have to manage devices, but more complex on the other, since they need to overcome security and authentication challenges.

The policies also create a win for the employees, who can become measurably more productive by being able to perform most tasks wherever it suits them and/or their employers. A recent CDW study indicated that IT buyers see smartphone and tablets increasing productivity, and reducing costs, with 75% of respondents mentioning

<sup>29</sup> PETER C. EVANS & MARCO ANNUNZIATA, GENERAL ELECTRIC, INDUSTRIAL INTERNET: PUSHING THE BOUNDARIES OF MINDS AND MACHINES 3 (Nov. 26, 2012), [http://www.ge.com/sites/default/files/Industrial\\_Internet.pdf](http://www.ge.com/sites/default/files/Industrial_Internet.pdf).

<sup>30</sup> Ibid.



productivity gains and another 25% stating significant productivity gains.<sup>31</sup> According to a recent study by Ecentix, 59% of knowledge workers claimed smartphones and tablets made them more productive, while another 27% asserted that working remotely makes work easier.<sup>32</sup> Indeed, although tablets often have less computing power than traditional laptops and desktops, their other myriad advantages are rendering them the device of choice for the knowledge worker. Tablets are lighter, less expensive, require less battery power, and can be operated with touch screens and, increasingly, through voice commands. Moreover, due to the light and large screens, sharing tablet results is a matter of handing the device over in collaborative work settings and they are almost perfect for “information consumption.”<sup>33</sup>

Unlike M2M applications that enable service firms to get leverage out of their workforces, and operate with significant fewer service workers, the productivity gains from tablets and smartphones are likely to be important, but not drive productivity to the same degree. IAE estimates that the U.S workforce will be about .25% more productive over the next five years, due to much more data being accessed remotely, thus reducing the need to be in the office or travel to customer sites.

### C. MOBILE PAYMENTS

The mobile payment arena is another technology that is poised for significant growth now that the complete build-out of wireless broadband networks is approaching. Consumers in the U.S. and the rest of the world are embracing mobile payments due to the convenience and speed of transactions, and because of the added safety that such platforms can provide. Merchants are opening up to such platforms to garner added sales, reduce checkout time, save employee time, and to bring the cash register/credit card machine to the consumer instead of requiring the consumer to enter a separate line or even the store itself to complete a transaction. A mobile or M-payment can be defined as any transaction where a mobile device is used to complete or authorize a transaction of financial value in return for goods and services. There are limitless ways that consumers and businesses can use mobile payments, from ordering air travel on a tablet to purchasing an on-demand movie at home or, from an industrial perspective, acknowledging payment of some new supplies that arrived in the nick of time to complete an order. Imagine buying the perfect gift during the crowded holiday season and having the salesperson “ring” you up with her/his tablet, saving you from wasting 20 minutes or more in line. Consumers are also checking balances, moving funds, paying bills, and conducting other banking transactions traditionally completed at banks or ATMs from their smartphones and tablets. According to Mobile Payment Overview, mobile payments can take five different forms:<sup>34</sup>

1. Mobile at the Point of Sale: Payment at the store through “Google Wallet” or another “tap and go” technology.
2. Mobile at the Point of Sale, where the merchant uses a smartphone or a tablet as a mobile cash register to take credit card or other payment data.

<sup>31</sup> See Nathan Eddy, *Tablet, Smartphone Use Increasing Worker Productivity*: CDW, eWEEK (May 16, 2012), <http://www.eweek.com/c/a/Mobile-and-Wireless/Tablet-Smartphone-Use-Increasing-Worker-Productivity-CDW-779688/>.

<sup>32</sup> See Fred Donovan, *Smartphones, Tablets Increase Workers’ Productivity, Survey Finds*, FIERCEMOBILEIT (Jan. 20, 2013), <http://www.fiercemobileit.com/story/smartphones-tablets-increase-workers-productivity-survey-finds/2013-01-20>.

<sup>33</sup> See Frank Gillett, *Why Tablets Will Become Our Primary Computing Device*, FORRESTER (Apr. 23, 2012), [http://blogs.forrester.com/frank\\_gillett/12-04-23-why\\_tablets\\_will\\_become\\_our\\_primary\\_computing\\_device](http://blogs.forrester.com/frank_gillett/12-04-23-why_tablets_will_become_our_primary_computing_device).

<sup>34</sup> See *The Most Important Mobile Payment Infographic*. Ever., MOBILE PAYMENTS TODAY, <http://www.mobilepaymentstoday.com/infographic.php?id=2> (last visited Sept. 18, 2013).

3. Mobile payment platforms that are emerging to facilitate bringing buyers and sellers together, like Paypal's new mobile payment service.
4. Direct carrier billing, where wireless operators are enabling customers to put items on their wireless invoice.
5. Closed Loop/Proprietary Systems, where select merchants set consumers up with their own cards/systems to speed transactions. Starbucks invested \$25 million in mobile payment firm Square so that its customers could race through their lines faster when purchasing their morning latte.<sup>35</sup>

The main driver of this business is the proliferation of smartphones and tablets that are making it easier for merchants and consumers to reduce transaction times during often time-consuming parts of the transaction. This is another example of the pervasiveness of wireless broadband infrastructure unleashing innovators and early adopters to create more efficient practices, anticipating and knowing that the networks will be there for their targeted customers.

While these services are in their infancy, the forecasts for the next several years are quite compelling. Gartner, Inc. projects that global mobile payment transaction values will grow from \$105.9 billion in 2011 to \$617 billion by 2016.<sup>36</sup> CapGemini projects that mobile payments will represent 15% of all payments by the end of 2013 and surpass credit card transactions by 2020.<sup>37</sup> The Yankee Group forecasts even faster growth anticipating that mobile payments will exceed a trillion dollars by the end of 2015 with North America representing about 35% of the growth.<sup>38</sup> The proliferation of smartphones and tablets has also made it easier for consumers to shop using their devices. It is not just air travelers who are adopting electronic boarding passes, an increasing number are using their devices to buy tickets and manage logistics. Jupiter Research expects such usage to move to 1 of 8 transactions by the end of 2015, and the transactions will include metro, concert, movie, bus, sports, and other entertainment tickets, in addition to air travel.<sup>39</sup> Mobile coupons will be another growth area and will expand to include delivery of government vouchers for aid, increasing efficiency and reducing the opportunity for fraud.

Many businesses and organizations will receive a host of benefits from the adoption of mobile payments. Transactions will be more secure, participants will save time by un-tethering point of sale, "middle men" will be unnecessary, and "leakage" from fewer cash transactions will be reduced. Moreover, both consumers and businesses can reduce their search times and costs due to the instant access to information that such devices provide. Overall, PricewaterhouseCoopers expects these and other effects to generate a net increase of \$13 billion in new annual rev-

<sup>35</sup> Claire Cain Miller, *Starbucks and Square to Team Up*, N.Y.TIMES (Aug. 8, 2012), <http://www.nytimes.com/2012/08/08/technology/starbucks-and-square-to-team-up.html>.

<sup>36</sup> See Press Release, Gartner, Inc., Gartner Says Worldwide Mobile Payment Transactions Value to Surpass \$171.5 Billion (May 29, 2012), <http://www.gartner.com/newsroom/id/2028315>.

<sup>37</sup> See Sarah Clark, *Mobile Payments To Overtake Cards Within Ten Years*, NFCWORLD (Sept. 14, 2011), <http://www.nfcworld.com/2011/09/14/39931/mobile-payments-to-overtake-cards-within-ten-years/>.

<sup>38</sup> See Press Release, Yankee Group, Yankee Group Sees Global Mobile Transactions Exceeding \$1 Trillion by 2015 (June 29, 2011), [http://www.yankeegroup.com/about\\_us/press\\_releases/2011-06-29.html](http://www.yankeegroup.com/about_us/press_releases/2011-06-29.html).

<sup>39</sup> See Press Release, Juniper Research, Mobiles to Become Tickets as 1 in 8 Mobile Users Expected to Use Mobile Ticketing by 2015 Says New Juniper Report (Mar. 2011), <http://www.juniperresearch.com/viewpressrelease.php?pr=234>.

enue for mobile payments service providers over the next five years.<sup>40</sup> It is not an accident that the mobile payment ecosystem is blossoming. Market participants, including venture capitalist investors, entrepreneurs, and retailers had to know and be assured that the mobile broadband networks would be available before they could fund and deploy such solutions.

#### D. MOBILE ENTERTAINMENT

Wireless broadband infrastructure has not only provided the “railways” or “highways” for productivity and employment advancements, it is also changing the way that people play, watch television and movies, read books and magazines, enjoy music, compete in games, share photos and use social media worldwide. It is also expanding the overall entertainment category. Smart portable devices are becoming the means of choice for those under the age of thirty to consume many forms of video, music, and information, while also interacting with each other. The entertainment industry groups smartphones and tablets together, referring to them as “the second screen.” Traditional players like ABC and HBO have launched mobile applications that make it easier for consumers to watch their favorite shows anywhere. This development has helped these companies maintain and grow their audiences. Importantly, new research indicates that the age divide is being crossed as more consumers over the age of forty are using tablets and smartphones for entertainment purposes. Mobile gaming is rapidly taking share away from consoles and desktops, and game developers are emphasizing mobile platforms for any new game development.

Content providers are similarly beginning to look at these portable and increasingly smart devices from two perspectives: first, as another distribution means for content originally developed for cable TV, network television, and the Internet; second, as an attractive alternative distribution path when compared to the more expensive cable and broadcast pathways.

Market leaders including Netflix, Amazon and Google are investing in original programming targeted at mobile users in the same way that many cable television networks, who had started by re-treading old programming from the major networks, began to develop original programming in order to accelerate growth a generation ago. The same forces that have changed book and music publishing in recent years are now beginning to expand the video and gaming sectors. Distribution to mobile devices is directly and immediately due to wireless broadband networks and infrastructure.

The global mobile entertainment market is projected to triple in size by the end of 2014 grossing \$54 billion, with Asia and Europe currently ahead of North America, with the North American market rapidly catching up.<sup>41</sup> The market is poised to grow at double-digit rates with music as the largest category, and video exhibiting the fastest growth rates.<sup>42</sup> TechNavio forecasts growth slightly under 10% per annum, with piracy representing the largest

---

<sup>40</sup> See PRICEWATERHOUSECOOPERS, *DIALING UP A STORM: HOW MOBILE PAYMENTS WILL CREATE THE MOST SIGNIFICANT REVENUE OPPORTUNITIES OF THE DECADE FOR FINANCIAL INSTITUTIONS* (Oct. 2011),

<http://www.pwc.com/us/en/financial-services/publications/viewpoints/assets/fs-viewpoint-mobile-payment-revenue-opportunities.pdf>.

<sup>41</sup> BUSINESS INSIGHTS, *THE MOBILE ENTERTAINMENT INDUSTRY OUTLOOK* (Apr. 2011).

<sup>42</sup> *Ibid.*

threat to monetizing the mobile entertainment opportunity.<sup>43</sup> The U.S. mobile entertainment market generated revenues of approximately \$7 billion in 2012.<sup>44</sup>

The earliest success story in mobile entertainment has been the rapid growth of the e-book sector, due to Amazon's Kindle, Barnes and Noble's Nook, Apple's iPad, among other e-book providers. By 2014, e-books will take a 25% share of the overall U.S. book market representing over \$2.45 billion of spending.<sup>45</sup> Increasingly, educators are looking at e-readers as a much less expensive means of getting textbook data into students' hands.<sup>46</sup>

So far, music has been the second large mobile entertainment market to emerge. According to e-marketer, the U.S. market for mobile music was \$5.7 billion in 2011.<sup>47</sup> This segment is also growing less than 10% per year due to the widespread use of piracy, and also the emergence of free music sharing sites, but mobile devices are continuing to garner share as the preferred means of listening to music. Apple recently announced that the company has surpassed the 25 billion mark for song downloads thus demonstrating the strong demand for music on the go.<sup>48</sup> Spotify and Pandora's Internet radio sites have grown rapidly by mixing a "freemium" model with paid subscriptions. Pandora's listener hours increased 16% from 2012 to 2013, and it has 72.1 million active listeners.<sup>49</sup>

The next largest entertainment market to emerge is that for mobile gaming. According to a recent analyst report this is another segment that is expected to triple by 2015 to \$7.5 billion in global revenue.<sup>50</sup> In the U.S. there are more than 100 million users, of which 21 million own tablets.<sup>51</sup> It is not surprising that 90% of gamers are under the age of 30, and 58% are male.<sup>52</sup> An estimated 4.2 million games are downloaded on the Apple operating system daily, according to the gaming firm, Newzoo. While much of this growth will be at the expense of existing game console and desktop competitors, some of it will be incremental and it is already having the effect of growing the overall gaming business category. Gamers are projected to spend over \$22 billion on "virtual goods" to be used inside games, demonstrating that new formats frequently create new revenue opportunities in addition to taking share from incumbent technologies.<sup>53</sup>

<sup>43</sup> TECHNAVIO, *THE GLOBAL MOBILE ENTERTAINMENT MARKET 2011-2015* (Nov. 2012).

<sup>44</sup> Ibid.

<sup>45</sup> See *eBook Market 2012: US, UK, Canada, Australia*, BWM BOOKS PTY. LTD. & LEAN MARKET RESEARCH (May 21, 2012), <http://www.bwmbooks.com/infographic-ebook-market-2012-us-uk-canada-australia-2>.

<sup>46</sup> See Nate Hoffelder, *Tablets to Replace Textbooks in New York Public Schools?*, THE DIGITAL READER (Jan. 27, 2013), <http://www.the-digital-reader.com/2013/01/27/tablets-to-replace-textbooks-in-new-york-public-schools/#.UjncoMakpSM>.

<sup>47</sup> See Press Release, Research & Markets, *New Global Music Report Analyzes the Changes That Are Transforming Music Markets Around the World* (May 30, 2007), <http://www.businesswire.com/news/home/20070530005505/en/Global-Music-Report-Analyzes-Transforming-Music-Markets>.

<sup>48</sup> See Press Release, Apple Inc., *iTunes Store Sets New Record with 25 Billion Songs Sold* (Feb. 6, 2013), <http://www.apple.com/pr/library/2013/02/06iTunes-Store-Sets-New-Record-with-25-Billion-Songs-Sold.html>.

<sup>49</sup> Press Release, Pandora, *Pandora Announces August 2013 Audience Metrics* (Sept. 5, 2013), <http://investor.pandora.com/phoenix.zhtml?c=227956&p=irol-newsArticle&ID=1852270&highlight=>.

<sup>50</sup> *F2P Mobile Gamers Spend Between \$8 and \$15 per Month*, SUPERDATA (Mar. 28, 2012), <http://www.superdataresearch.com/blog/f2p-mobile-gamers-spend-between-8-and-15-per-month>.

<sup>51</sup> See *Mobile Games Trend Report*, Newzoo (Mar. 28, 2012), <http://www.mobile-ent.biz/reports/read/newzoo-mobile-games-trend-report>.

<sup>52</sup> Ibid.

<sup>53</sup> See Atul Bagga, Senior Research Analyst, Lazard Capital Markets, Presentation, *Emerging Trends in Games-as-a-Service* at the Game Developers Conference® Online 2011 (Oct. 2011), [http://twvideo01.ubm-us.net/o1/vault/gdconline11/Atul\\_Bagga\\_Business\\_Emerging%20Trends%20In%20GaaS.pdf](http://twvideo01.ubm-us.net/o1/vault/gdconline11/Atul_Bagga_Business_Emerging%20Trends%20In%20GaaS.pdf).

The “second screen” is also becoming an increasingly embraced screen of choice for video viewing. Hulu, Netflix, and Google’s YouTube divisions surpassed \$4 billion in revenues in 2011, and had healthy double-digit growth in 2012.<sup>54</sup> These firms are sponsoring original programming in the same way that cable firms did a generation ago. Importantly, people are migrating from portals like Yahoo to social networking as the means of choice for accessing the Internet and mobile is rapidly gaining share within social media in how they access the Internet. Facebook and other social networking sites have had to pivot rapidly to ensure that their applications and user interfaces are mobile/smartphone friendly. According to recent data, announced by Facebook, one seventh of the world’s population is on Facebook’s site and the number of mobile users is growing rapidly and represents Facebook’s fastest growing advertising revenue category.<sup>55</sup>

The emergence of mobile entertainment is clearly having a profound business impact on the entertainment and information sectors of the T-I-E industry. Print media is losing market share and advertising revenue, cable TV and broadcast television are witnessing slow growth, music and book publishing are undergoing seismic shifts in how they are used and derive revenue, while entertainment on mobile devices is booming. The net effect is that the overall entertainment category is expanding. PricewaterhouseCoopers projects that U.S. spending for entertainment and media spending will grow to \$555 billion in 2015 at an annual compounded growth rate of 4.6 %.<sup>56</sup> While some analysts predict that new media will obliterate old media, the new forms tend to expand the aggregate market even as they curb growth or take share away from incumbent technologies. The advent of FM radio grew the overall radio market while driving AM to a largely news and talk format, and cable television grew the overall television market causing broadcast television to refresh and reinvent its programming choices. Even today broadcast networks command higher advertising rates than cable TV networks.

We see the same trend emerging with the U.S. entertainment sector. While there will be some concentrated pain, for example the decline of print media, new formats will continue to create additional consumer choices that will lead to overall growth. Importantly, new devices, applications, and services are also changing consumer behavior. People are experimenting and adapting to new ways of how they use wireless and Internet delivered media, buy and sell goods and services, read books, listen to music, play games, text, and interact with friends, colleagues and acquaintances.

## VI. ECONOMIC MODEL AND DISCUSSION

In order to estimate the complete economic and employment effects of additional wireless broadband investments, we must consider both the direct effects using conventional Keynesian analysis, as well as the influence of disruptive/enabling technologies on productivity and economic growth. To model this latter “innovation/infrastructure” effect with a top-down perspective, we use historical evidence and statistical relations from major technological

<sup>54</sup> See Marcelo Ballvé, Henry Blodget & Alex Cocotas, Presentation, *The Future of Digital* at the IGNITION: Future of Digital Conference (Nov. 2012), <http://www.businessinsider.com/future-of-digital-slides-2012-11?op=1>.

<sup>55</sup> See Peter Sayer, *Facebook Says 1 Billion Use the Service Each Month*, COMPUTERWORLD INC. (Oct. 4, 2012), [http://www.computerworld.com/s/article/9232045/Facebook\\_says\\_1\\_billion\\_use\\_the\\_service\\_each\\_month](http://www.computerworld.com/s/article/9232045/Facebook_says_1_billion_use_the_service_each_month).

<sup>56</sup> See Stuart Elliott, *Study Finds Rebound in Entertainment & Media Spending*, NYT MEDIA DECODER (Jun. 14, 2011), <http://mediadecoder.blogs.nytimes.com/2011/06/14/study-finds-rebound-in-entertainment-and-media-spending>.

advances, such as the deployment of the railroad, electric, and Internet infrastructures. We also employ a bottom-up approach using industry-generated and IAE projections as an alternative and validating measure of the economic effects of a disruptive technology, such as a near-ubiquitous, universal, interoperable and affordable wireless broadband service.

## A. THE KEYNESIAN EFFECT

The primary effects, or Keynesian effects, of wireless broadband investment on the overall economy encompass three separate influences: *direct*, *indirect* and *induced* effects. Direct effects are jobs and additional economic activity generated by expanding the broadband infrastructure, while indirect effects include additional economic growth related to job gains associated with businesses that are downstream and upstream of the broadband network, *e.g.*, communications equipment suppliers, commodity producers, *etc.* Lastly, induced effects on the economy are jobs and income created stemming from the additional personal income generated by the direct and indirect effects, *e.g.*, restaurant workers, hotel staff, *etc.* These three effects are considered to be the key elements of a traditional Keynesian analysis.

To quantify the Keynesian effects, we use two different methods. The first approach is based on an econometric analysis by Koutroumpis (2009) to demonstrate how broadband penetration rates affect economic growth. As noted in Section II, the impact of broadband is stronger when it reaches a critical mass of users, *i.e.*, above 30% of the population according to Koutroumpis, and thus we use this heightened econometric sensitivity factor (0.0023) to estimate the impact of greater broadband penetration on GDP over our 5-year forecast horizon, 2013-2017. As shown in the table below, this results in a direct increase in nominal GDP of 0.21% per year by 2017.<sup>57</sup>

We also use a conventional input-output multiplier method to provide an alternative estimate of the direct effects on GDP based on an average of economic output multipliers from the broadcasting and telecommunications industry (see CESP, 2009), as well as the regional construction industry (BEA, 2003). This average multiplier of 2.448 is then multiplied by our annual projections for U.S. wireless broadband capital expenditures. Between 2012 and 2016, iGR forecasts total U.S. Long Term Evolution (LTE) infrastructure capital expenditures to be \$39.82 billion, based on the anticipated growth of LTE subscribers and data traffic on the networks. Infonetics expects worldwide LTE capex to spike in 2012, before leveling out in 2015 and 2016 at around the US \$345 billion mark (Infonetics CapEx Projections). In contrast to these larger figures, we estimate a more conservative investment activity trend, based more narrowly on projections from Ovum and adjusted by IAE to reflect U.S.-only capital investment (rather than all of North America). Thus, our estimates start with a 2013 forecast level of \$35.4 billion for U.S.-only wireless broadband capital expenditures.<sup>58</sup>

<sup>57</sup> In the Appendix, we report a more detailed version of all tables reported here, along with more descriptions of the assumptions underlying the estimates.

<sup>58</sup> The Ovum forecast for North American Wireless Capital Expenditures was obtained via the Business Industries (BI) function provided by Bloomberg LLP.



The table below demonstrates that this approach yields a larger impact on economic growth of 0.54% to 0.55% per year during 2013–2017. Overall, the direct, Keynesian impact on the economy by 2017 is quite substantial with estimates varying from 0.21% via the econometric approach to 0.55% based on the multiplier method.

**TABLE A: DIRECT EFFECTS ON GDP OF WIRELESS CAPEX (\$BILLIONS OR %)**

	2013	2014	2015	2016	2017
<b>Broadband Penetration Rate (as a % of U.S. population)</b>	82%	85%	88%	90%	93%
<b>Annual \$ Chg. In GDP with Econometric Sensitivity Factor (0.0023x)</b>	\$29.853	\$30.946	\$32.038	\$32.766	\$33.858
<b>Total Incremental Wireless Broadband Capital Expenditures</b>	\$35.430	\$34.793	\$34.984	\$35.065	\$35.613
<b>Annual \$ Chg. In GDP with Multiplier Effect (2.448x)</b>	\$86.739	\$85.178	\$85.645	\$85.843	\$87.186
<b>Annual % Chg. In GDP with Econometric Sensitivity Factor Effect</b>	0.19%	0.20%	0.20%	0.21%	0.21%
<b>Annual % Chg. In GDP with Multiplier Effect</b>	0.55%	0.54%	0.54%	0.54%	0.55%

## B. INNOVATION AND NETWORK EFFECTS

IAE uses both top-down and bottom-up analyses to quantify the projected impact that the wireless broadband enabled technologies will have on the U.S. economy over the next five years. From a top down approach, IAE examined the impact that previous enabling technologies have had on the aggregate economy, once such technologies became widely available and embraced by businesses and consumers. Specifically, IAE reviewed the academic literature on:

- The railroad system;
- The advent of electricity;
- The Internet.

Once these disruptive technologies became pervasive and reached critical mass, IAE's analysis of GDP growth and employment activity reveals that productivity and GDP accelerate sharply in subsequent decades. As noted earlier,

Gordon (1999, 2012) has identified three “industrial revolutions” referred to as “IR1” (roughly, 1750–1830), “IR2” (1870–1900), and “IR3” (1960–2000) in order to measure the impact of innovation on economic growth and productivity. He observes large increases in both productivity and economic growth in each of these eras and uses over a century of detailed data, from 1891–2012, in order to examine innovation effects on the U.S. macro-economy. Using these data, we find that the ratio of GDP growth-to-productivity growth exceeds one (at 1.56x during this 1891–2012 period). Thus, we can use Gordon’s estimates, along with IAE’s own analysis, to compute a projected range for the impact that near-ubiquitous wireless broadband service might and/or will have on the economy during the next five years. In addition, we can compare this top-down quantification with a bottom-up approach that examines new applications that have been made possible by the ubiquity of wireless broadband. IAE reviewed the following:

- M2M or the “Internet of Things” technologies.
- Mobile payments and marketplaces.
- Non-M2M mobile productivity applications.
- Mobile entertainment.

IAE examined industry projections on each of these technologies in order to build a model that summarizes the impact of each one on the economy. Specifically, IAE examined investment, productivity improvement, GDP, and employment due to the roll-out of new products and services in the mobile categories noted above.

Presented below are the “innovation” and “network” related effects of wireless broadband investment on GDP growth in the U.S. The first three rows use the top-down approach based on Gordon (1999, 2012), while the subsequent seven rows report the bottom-up results using industry and IAE projections. As described in Section III, once disruptive technological innovations become widely available, they can have large and long-lasting positive effects on productivity and economic growth that far outweigh the initial investments in these innovations. Accordingly, we assume the top-down change in productivity gradually increases to an additional 1.08% per year, which is equivalent to the jump in U.S. productivity achieved during the Internet-led economic expansion from 1996 to 2004. Consistent with estimates of growth and productivity reported in Gordon (2012), the projected increase in productivity was converted into a GDP growth estimate by using the 1891–2012 historical average ratio of GDP growth-to-productivity growth (1.56x).

To provide an alternative perspective on innovation/network effects, we also performed a bottom-up analysis of wireless broadband effects on the economy by examining how an increase in the penetration of this service can generate additional revenue through new products, services, and applications related to M2M technology, mobile payments, non-M2M productivity improvements, and mobile entertainment. This bottom-up increase in productivity is based on GE’s “Internet of Things” forecast and internal IAE projections. To be conservative, we estimated that this impact on M2M and non-M2M technologies is focused solely on 50% of economic activity rather than the entire economy (based on BEA real GDP data for Q4 2012). This assumption acknowledges that about half of all firms/industries will be slow to adopt M2M and other mobile-based technological innovations over the next 5 years. Consistent with Gordon, the impact of greater productivity on increased revenue (and thus higher GDP) relies on the same 1.56x ratio based on the 1891–2012 historical average relationship between GDP and productivity growth.

We anticipate and predict a modest impact on the economy from mobile payments since this service may simply cannibalize some electronic payments that consumers already conduct via computer-based online bill-pay software. We concur with an industry estimate developed in PWC (2011) which forecasts \$13 billion per year in additional mobile payment revenue over the next five years, due to near-ubiquitous availability of smart phones and wireless broadband in the U.S.

The final component of the bottom-up estimate is the impact of wireless broadband on mobile entertainment. Similar to mobile payments, IAE predicts that some of the revenue from mobile entertainment will cannibalize existing entertainment spending, but on balance, the overall entertainment “pie” will be enlarged by this innovation. We adopt a PricewaterhouseCoopers industry forecast of 4.6% compound annual growth rate (CAGR) through 2015. Starting from an existing base of \$443 billion spending on entertainment in 2010, the additional annual revenue in dollar terms ranges between \$22 billion and \$27 billion over the next five years.

The final two rows of Table B outline the estimated percentage change in GDP, where the bottom-up approach is reported as the “Low Estimate”, while the projections based on the topdown method represent the “Moderate Estimate.” Both sets of estimates report sizable economic gains, ranging from 1.42% to 1.69% of annual GDP in 2017. Within the bottom-up forecast, we can see that M2M will have the biggest economic impact by 2017 (\$123.7 billion), followed by non-M2M productivity effects (\$61.8 billion), mobile entertainment (\$26.7 billion), and mobile payments (\$13 billion). In addition, both the top-down and bottom-up approaches show that innovation/network effects will represent the bulk of the economic growth created by additional wireless broadband investment over the five year forecast period.

**TABLE B:** NETWORK/INNOVATION EFFECTS ON GDP OF INCREASED BROADBAND DUE TO ADDITIONAL WIRELESS CAPEX (\$BILLIONS)

	2013	2014	2015	2016	2017
<b>Top-Down Macro Approach based on historical experience:</b>					
<b>Incremental % Change in Total Productivity (% change in output / hour)</b>	0.22%	0.44%	0.65%	0.87%	1.08%
<b>Annual \$ Impact of Productivity Shock on nominal GDP growth</b>	\$54.418	\$107.847	\$161.275	\$214.704	\$268.132
<b>Annual % Chg. in nominal GDP due to Productivity Shock</b>	0.34%	0.68%	1.02%	1.36%	1.69%

**TABLE B:** NETWORK/INNOVATION EFFECTS ON GDP OF INCREASED BROADBAND DUE TO ADDITIONAL WIRELESS CAPEX (\$BILLIONS) – CONTINUED

	2013	2014	2015	2016	2017
<b>Bottom-Up Micro Approach based on new product revenues:</b>					
<b>Machine-to-Machine (M2M) Change in Private Sector Productivity</b>	0.10%	0.30%	0.50%	0.75%	1.00%
<b>M2M Incremental \$ Revenue</b>	\$12.368	\$37.103	\$61.839	\$92.758	\$123.677
<b>Mobile Payments Incremental Revenue</b>	\$5.000	\$7.000	\$10.000	\$11.000	\$13.000
<b>Non-M2M Productivity Improvement due to Mobile Innovations</b>	0.05%	0.15%	0.18%	0.21%	0.25%
<b>Mobile Productivity Effects on Incremental Revenue</b>	\$12.368	\$37.103	\$44.524	\$51.944	\$61.839
<b>Mobile Entertainment Revenue: Net Incremental \$ Change</b>	\$22.310	\$23.336	\$24.410	\$25.533	\$26.707
<b>Mobile Entertainment Revenue: Net incremental % Change</b>	4.60%	4.60%	4.60%	4.60%	4.60%
<b>Low Estimate of Total \$ Impact on nominal GDP (Sum of above Bottom-Up Revenue figures)</b>	\$52.045	\$104.543	\$140.772	\$181.235	\$225.223
<b>Moderate Estimate of \$ Impact on nominal GDP (Top-Down Approach)</b>	\$54.418	\$107.847	\$161.275	\$214.704	\$268.132
<b>Low Estimate of % Change in GDP</b>	0.33%	0.66%	0.89%	1.14%	1.42%
<b>Moderate Estimate of % Change in GDP</b>	0.34%	0.68%	1.02%	1.36%	1.69%

### C. THE SUMMED EFFECTS

In the next table, we sum the direct effects on the economy of additional wireless broadband investment (Table A) with the innovation/network-related effects (Table B). Table C displays a “Low Estimate” which is based on the lower projections found in Tables A and B. This Low Estimate of the “total” effect on GDP is based on the Koutroumpis (2009) econometric sensitivity estimates, and the bottom-up estimates of the innovation/network effects. In addition, Table C presents a “Moderate Estimate” of the total effect by summing the projections based on the conventional multiplier method of Table A and the top-down forecasts of the innovation/network effects.

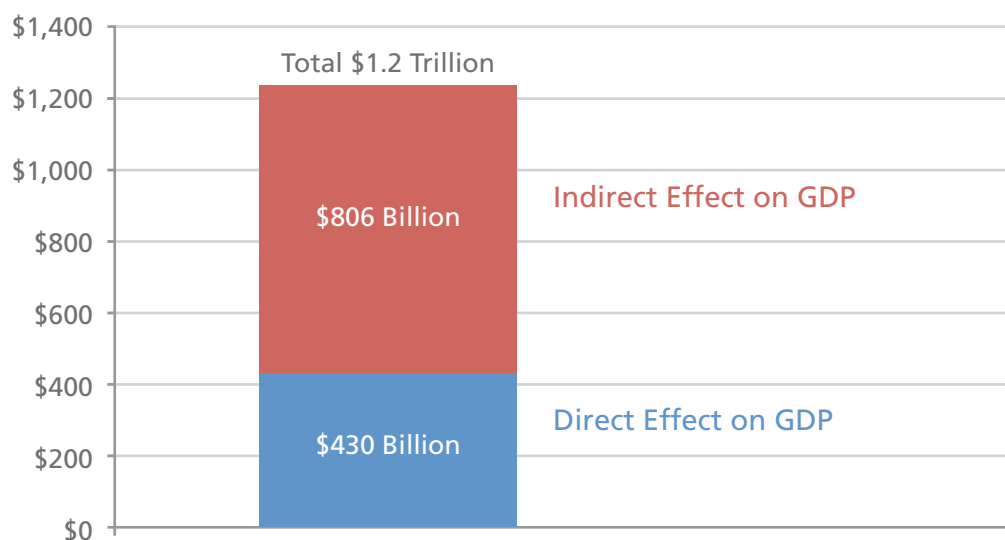
Overall, the analysis suggests that the total effect on the economy can be substantial, rising to a range of 1.64% to 2.24% of annual GDP by 2017. Most importantly, a large proportion of this increase in GDP is attributable to the effects of wireless broadband on innovation, rather than the traditional Keynesian effects. For example, the share of GDP growth in 2017 contributed by innovation is expected to be between 75% and 87% for the Moderate and Low estimates, respectively.<sup>59</sup> This result highlights the importance of wireless broadband service as a disruptive, yet enabling, factor that can help spur economic growth via the creation of new business models and greater overall productivity.

**TABLE C:** TOTAL EFFECTS ON GDP OF INCREASED BROADBAND USAGE DUE TO ADDITIONAL WIRELESS CAPEX (\$BILLIONS OR %)

	2013	2014	2015	2016	2017
<b>Low Estimate of \$ Impact on nominal GDP</b>	\$81.899	\$135.488	\$172.810	\$214.001	\$259.081
<b>Moderate Estimate of \$ Impact on nominal GDP</b>	\$141.157	\$193.025	\$246.920	\$300.547	\$355.318
<b>Low Estimate of Cumulative % Chg. in nominal GDP</b>	0.52%	0.86%	1.09%	1.35%	1.64%
<b>Moderate Estimate of Cumulative % Chg. in nominal GDP</b>	0.89%	1.22%	1.56%	1.90%	2.24%

<sup>59</sup> To compute this, we divide the 2017 percentage increase in GDP due to innovation (e.g., 1.69% for the Moderate Estimate) by the total percentage increase in 2017 (2.24% for the Moderate Estimate) and obtain 75.5%. For the Low Estimate, we divide 1.42% by 1.64% to report an 86.9% share.

## TOTAL EFFECT ON GDP (IN BILLIONS)



## D. THE IMPACT ON EMPLOYMENT

The final phase of our analysis estimated the impact of increased U.S. wireless broadband investment on job growth. As noted in Section I, disruptive technologies such as wireless broadband can affect employment in various ways, for example directly, through increased wireless infrastructure jobs, and indirectly, via up- and down-stream industries, and also by inducing new jobs in local economies. Lastly, and perhaps most importantly, employment will be affected by innovations in goods and services due to the near-ubiquity of wireless broadband service deployment. As Katz (2012), among others, points out, this mobile-related innovation can help create jobs, as well as destroy jobs. However, the Katz survey of research related to the overall impact of broadband on employment shows that, on a net basis, the impact is positive.

Accordingly, we estimate that the effect of wireless broadband investment in the U.S. on jobs using two alternative methods. First, we use a bottom-up “job multiplier” approach, as developed in Katz (2012), Atkinson *et al.* (2009), and others. As outlined below in the first four rows of Table D, the direct job growth is derived from the Ovum and IAE capex forecast data in order to quantify the level of capex supporting each wireless industry worker (\$110,000). This number is then divided into the incremental component of the IAE capex projections reported in Table A, *i.e.*, capex spending above the past level of \$32.5 billion.

Once we have this “Direct Effect on Job Creation” (found in the first row of Table D), we can then apply job multipliers to determine how many indirect, induced, and innovation-related jobs are created. Overall, this job multiplier approach yields a cumulative gain of 322,562 jobs (0.23% of today’s workforce).

For added robustness, we also used another method to estimate the impact on employment. This alternative approach relies on econometric and other statistical analyses that relate broadband penetration rates to job growth, as noted in Katz (2012). Using the low end of the range of sensitivity factors (0.20x the change in broadband penetration), we



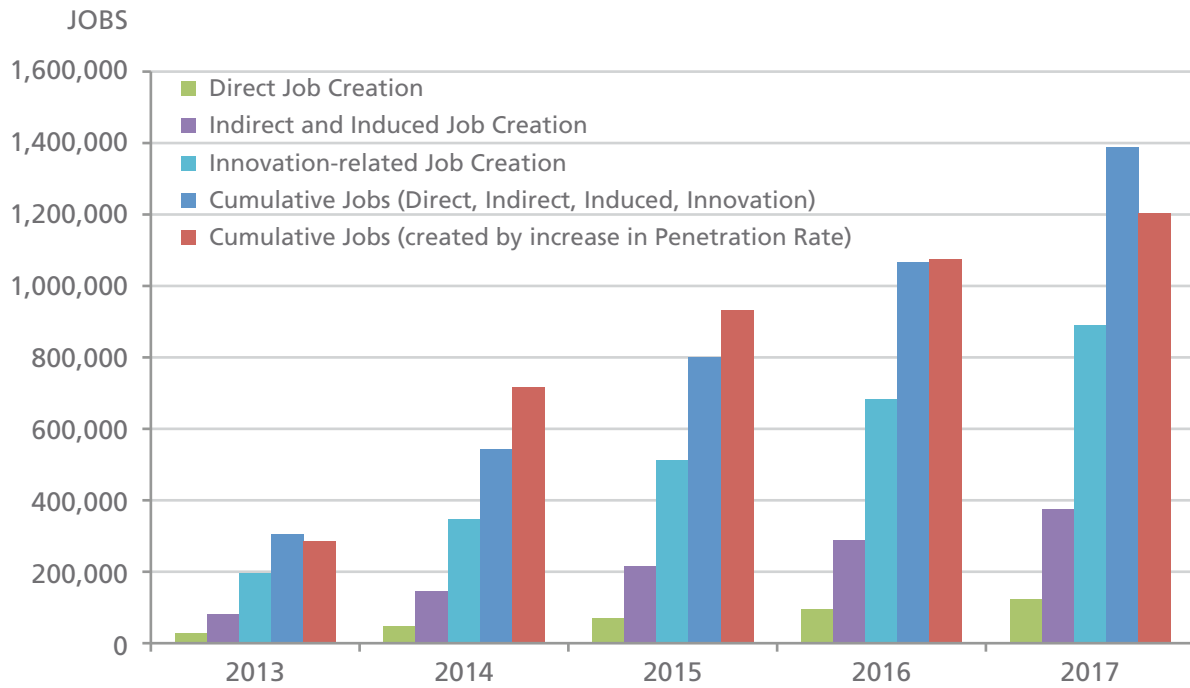
show a substantially greater increase in employment with this method (1,203,762 or 0.84% of the labor force). This increase occurs even though we adjust the sensitivity factor down from 0.20x to 0.05x over the forecast period (based on our assumption that the impact on jobs might diminish as broadband approaches near-ubiquitous coverage).

**TABLE D:** IMPACT OF ADDITIONAL WIRELESS CAPEX ON U.S. EMPLOYMENT (IN NUMBER OF JOBS OR %)

	2013	2014	2015	2016	2017
<b>Direct Effect on Job Creation</b> (assumes \$110K Capex per job above \$32.5 Billion)	26,777	20,982	22,714	23,450	28,436
<b>Indirect &amp; Induced Job Creation</b> (via average 'job multiplier' of 3.063x)	82,027	64,274	69,580	71,836	87,110
<b>Innovation-related Job Creation</b> (via 'network multiple' of 7.28x)	194,937	152,747	165,357	170,719	207,016
<b>Cumulative Jobs Created</b> (Direct, Indirect, Induced and Innovation-related)	<b>303,740</b>	<b>238,003</b>	<b>257,651</b>	<b>266,006</b>	<b>322,562</b>
<b>Change in Broadband Penetration</b> <b>Rate (as a % of U.S. population)</b>	1%	3%	3%	2%	3%
<b>Annual Jobs Created</b> (using Sensitivity to Penetration Rate, 0.05 – 0.2x)	286,610	429,915	214,958	143,305	128,975
<b>Cumulative Jobs Created (based</b> <b>on Growth in Penetration Rate)</b>	<b>286,610</b>	<b>716,525</b>	<b>931,482</b>	<b>1,074,788</b>	<b>1,203,762</b>
<b>Low Estimate of Effect</b> <b>on % Cumulative Growth</b> <b>in Employment</b>	0.21%	0.17%	0.18%	0.19%	0.23%
<b>Moderate Estimate of Effect</b> <b>on % Cumulative Growth</b> <b>in Employment</b>	0.20%	0.50%	0.65%	0.75%	0.84%

In sum, the continued investment in U.S. wireless broadband services and infrastructure can lead to substantial gains in economic growth (between 1.6% and 2.2%) and jobs (0.2% to 0.8%) when innovation-related influences, as well as Keynesian effects, are considered.

## IMPACT OF WIRELESS CAPEX ON JOB CREATION



## VII. CONCLUSIONS

1. It is clear, from data presented in this research report, that wireless broadband represents major positive and continued effects on U.S. job creation and economic growth over the next five years.
2. The indirect or “spillover” economic growth and employment benefits derived from wireless broadband are sizable, and will continue to be substantial beyond the next five years.
3. The economic and employment benefits enabled by the deployment of wireless broadband infrastructure depend on the public’s access to the infrastructure along with the services and applications offered. Investment in broadband-enabled services and applications is contingent on broad access by consumers regardless of their income or location (rural or urban).
4. The deployment of fast and more robust available and affordable 4G networks will accelerate innovation that will ripple rapidly through the U.S. economy. The deployment of this wireless infrastructure may equal, in terms of economic impact, the universal deployment of the railroad, electric and Internet infrastructures.
5. New technologies and innovation in the form of services and applications will likely take forms beyond the categories examined in this report. mHealth, for example, could emerge to create larger economic benefits than M2M broadly, if and when innovators determine how to develop applications that drive costs out of the health care sector while providing quality care for a larger portion of the population. Similarly, both public and private education could be overhauled via technologies that ride on mobile broadband networks and equipment.
6. In order to pave the way to this “new normal”, policy makers and politicians must continue to encourage the rapid deployment of nationwide, ubiquitous and affordable wireless broadband on an equal and non-discriminatory basis by removing any barriers that hinder the acceleration of infrastructure deployment (site acquisition, technology upgrades, etc.). Rapid network build out is an employment and economic growth imperative.
7. The net effect on jobs will be positive, after accounting for some job losses in certain sectors of the economy due to, among other things, increased efficiency. This welldocumented effect of disruptive technologies provides policy makers with ample opportunity to plan for additional resources and training for those sectors that may be impacted.

## REFERENCES

- Atkinson, R., Castro, D. & Ezell, S.J. (2009). *The digital road to recovery: a stimulus plan to create jobs, boost productivity and revitalize America*. The Information Technology and Innovation Foundation, Washington, D.C.
- California Economic Strategy Panel. (2009). *Using Multipliers to Measure Economic Impacts*. Retrieved from: [dside.org/wp-content/uploads/2011/11/Using\\_Multipliers\\_to\\_Measure\\_Economic\\_Impacts.pdf](http://dside.org/wp-content/uploads/2011/11/Using_Multipliers_to_Measure_Economic_Impacts.pdf)
- Crafts, N. (2004). Productivity Growth in the Industrial Revolution: A New Growth Accounting Perspective. *Journal of Economic History* 64, 521-535.
- Crandall, R., Jackson, C., and Singer, H. (2003). *The Effect of Ubiquitous Broadband Adoption on Investment, Jobs, and the U.S. Economy*. Washington D.C.: Criterion Economics.
- Crandall, R., Lehr, W., and Litan, R. (2007). The Effects of Broadband Deployment on Output and Employment: A Cross-sectional Analysis of U.S. Data. *Issues in Economic Policy*, 6.
- Czernich, N., Falck, O., Kretschmer T., and Woessman, L. (2009, December). Broadband infrastructure and economic growth (CESifo Working Paper No. 2861). Retrieved from: [www.ifo.de/DocCIDL/cesifo1\\_wp2861.pdf](http://www.ifo.de/DocCIDL/cesifo1_wp2861.pdf)
- Evans, P.C. and Annunziata, M. (2012). Industrial Internet: Pushing the Boundaries of Minds and Machines. (General Electric). Retrieved from: <http://files.gereports.com/wp-content/uploads/2012/11/ge-industrial-internet-vision-paper.pdf>
- Fornefeld, M., Delaunay, G. and Elixmann, D. (2008). *The Impact of Broadband on Growth and Productivity*. A study on behalf of the European Commission (DG Information Society and Media), MICUS.
- Gillett, S., Lehr, W., and Osorio, C., and Sirbu, M. A. (2006). *Measuring Broadband's Economic Impact*. Technical Report 99-07-13829, National Technical Assistance, Training, Research, and Evaluation Project.
- Gordon, R.J. (1999). U.S. economic growth since 1870: One big wave? *American Economic Review* 89, 123-128.
- Gordon, R.J. (2012). Is U.S. economic growth over? Faltering innovation confronts the six headwinds. *CEPR Policy Insight* No. 63, 1-13.
- Jorgenson, D.W. (2001). Information technology and the U.S. economy. *American Economic Review* 91, 1-32.
- Jorgenson, D.W., Ho, M., and Stiroh, K. (2006a). *The industry origins of the American productivity resurgence*.
- Jorgenson, D.W., Ho, M., Samuels, J., and Stiroh, K. (2006b). Productivity growth in the new millennium and its industry origins. Paper presented at the 2006 Intermediate Input-Output Meeting July 26-28, Sendai, Japan.
- Katz, R., L. (2012). *The Impact of Broadband on the Economy: Research to Date and Policy Issues*, ITU report, April.
- Katz, R., L. and Suter, S. (2009). *Estimating the economic impact of the broadband stimulus plan* (Columbia Institute for Tele-Information Working Paper). Retrieved from: [www.elinoam.com/raulkatz/Dr\\_Raul\\_Katz\\_-\\_BB\\_Stimulus\\_Working\\_Paper.pdf](http://www.elinoam.com/raulkatz/Dr_Raul_Katz_-_BB_Stimulus_Working_Paper.pdf)
- Koutroumpis, P. (2009). The Economic Impact of Broadband on Growth: A Simultaneous Approach. *Telecommunications Policy*, 33, 471-485.
- Martínez, D., Rodríguez, J. and Torres, J.L. (2010). ICT-specific technological change and productivity growth in the U.S.: 1980-2004. *Information Economics and Policy* 22, 121-129.
- Pearce, A., and Pagano, M.S. (2009). Accelerated Wireless Broadband Infrastructure Deployment: The Impact on GDP and Employment, *Media Law & Policy* 18, 105-127.
- Pearce, A. Goodstadt, B., and Agarwal, A. (2011). Technology, Business & Policy Implications as the Communications Ecosystem Moves from POTS to PANS, *Media Law & Policy* 20, 47-93.
- Prados de la Escosura, L., and Roses, J.R. (2009). The Sources of Long-Run Growth in Spain, 1850-2000. *Journal of Economic History* 69, 1063-1091.
- PriceWaterhouseCoopers LLP. (2011). Dialing up a Storm: How Mobile Payments Will Create the Most Significant Revenue Opportunities of the Decade for Financial Institutions. Retrieved from [www.pwc.com/fsi](http://www.pwc.com/fsi)
- Roeller, L-H. and Waverman, L. (2001). Telecommunications Infrastructure and Economic Development: A Simultaneous Approach. *The American Economic Review*, 91, 909-923.
- Sandage, T. (2012). Live and unplugged, *The Economist*, The World in 2013 issue, 125-126.
- Shideler, D., Badasyan, N., and Taylor, L. (2007, September 28-30). The economic impact of broadband deployment in Kentucky. *Telecommunication Policy Research Conference*, Washington D.C.
- Thompson, H., & Garbacz, C. (2008). Broadband Impacts on State GDP: Direct and Indirect Impacts. Paper presented at the International Telecommunications Society 17th Biennial Conference, Canada.
- Thompson, H., & Garbacz, C. (2011). Economic impacts of mobile versus fixed broadband, *Telecommunications Policy*, 35, 999-1009.

## RESEARCH TEAM

The IAE research team has extensive and unchallenged wireless sector knowledge and experience which renders it ideally suited to add significant value to this complex project. The IAE team – Drs. Alan Pearce and Michael Pagano, along with Richard Carlson – has a unique blend of hard-nosed, practical and successful business experience, in-depth industry knowledge, and a thorough understanding of the complex regulatory structure, an extensive industry, technology and regulatory/policy contacts, coupled with distinguished academic work, grounded in sound business and economic theory and know-how.

**Dr. Alan Pearce**, IAE's President and founder, is a widely recognized expert in the business and regulation of the telecommunications-information-entertainment (T-I-E) industry having served as the Chief Economist of the Federal Communications Commission for five years, and held similar positions on Capitol Hill and in the Executive Office of the President prior to forming IAE. He is an acknowledged expert on the business, technology and regulatory policy implications on the various participants in the T-I-E ecosystem, and is recognized as a leading expert in the rapid development and deployment of the wireless sector services and applications going back to its beginnings (prior to October, 1983). Pearce has consulted, researched and acted as a “go-to” expert for most major wireless sector participants, including McCaw Communications (acquired by AT&T Wireless), Cingular Wireless, AT&T Mobility, AirTouch (acquired by Vodafone and merged into what is now Verizon Wireless), T-Mobile USA, the CTIA, PCIA – The Wireless Infrastructure Association, along with handset and other equipment manufacturers, *etc.* He has also provided research and consulting services to international carriers in Europe, Australia, Canada, Asia and Latin America.

**J. Richard Carlson** has spent most of his 22-year career in leadership positions at various wireless and technology companies serving as President and CEO and VP of Sales/Marketing. Of specific and particular relevance, Mr. Carlson was recently CEO of Wireless Matrix, one of the early and leading M2M wireless application companies. Rich led the Company's transformation to an early innovator of broadband wireless applications serving the fleet management market. Carlson has also teamed with Dr. Alan Pearce on economic and industry studies of the wireless and satellite sectors, and assisted Pearce in working on Cingular's record setting \$41 billion all-cash acquisition of AT&T Wireless (AWS) in 2004.

**Dr. Michael Pagano** is The Robert J. and Mary Ellen Darretta Endowed Chair in Finance at Villanova University. Professor Pagano conducts empirical and theoretical analyses related to issues in market microstructure, financial institution management, risk management, international finance, and cost of capital estimation. He has published in numerous finance journals and is an associate editor of *The Financial Review*. Professor Pagano has broad business, consulting and media experience, and is also a commentator on financial institutions and market structure issues and has been quoted in media sources including *The Wall Street Journal*, *The New York Times*, *The Financial Times*, *the Associated Press*, *CNBC*, *Bloomberg TV*, *PBS's Nightly Business Report*, *Wall Street Journal Radio*, and *Bloomberg Radio*.

**APPENDIX. Estimated Effects on Nominal GDP and Total Employment due to Increased Wireless Broadband Investment (in \$ bil. or %):\***

Item	A. Direct Effects on GDP of Wireless Capex	Source	2013	2014	2015	2016	2017
1	Broadband Penetration Rate (as a % of U.S. population)	IAE, Analysys Mason (2012)	82%	85%	88%	90%	93%
2	Annual \$ Chg. In GDP with Econometric Sensitivity Factor (0.0023x)	Koutroumpis (2009)	\$ 29.853	\$ 30.946	\$ 32.038	\$ 32.766	\$ 33.858
3	Total Incremental Wireless Broadband Capital Expenditures	Ovum (2013), IAE	\$ 35.430	\$ 34.793	\$ 34.984	\$ 35.065	\$ 35.613
4	Cumulative \$ Chg. In GDP with Multiplier Effect (2.448x)	CESP (2009), BEA (2003)	\$ 86.739	\$ 85.178	\$ 85.645	\$ 85.843	\$ 87.186
5	Annual % Chg. In GDP with Econometric Sensitivity Factor Effect		0.19%	0.20%	0.20%	0.21%	0.21%
6	Annual % Chg. In GDP with Multiplier Effect		0.55%	0.54%	0.54%	0.54%	0.55%
<b>B. Network / Innovation Effects on GDP of Increased Broadband Usage due to Additional Wireless Capex</b>							
		Source	2013	2014	2015	2016	2017
<i>Top-Down Macro Approach based on historical experience:</i>							
7	Incremental Change in Total Productivity (% change in output per hour)	Gordon (1999, 2012), St. Louis Federal Reserve Bank data	0.22%	0.44%	0.65%	0.87%	1.08%
8	Annual \$ Impact of Productivity Shock on nominal GDP growth	Gordon (1999, 2012)	\$ 54.418	\$ 107.847	\$ 161.275	\$ 214.704	\$ 268.132
9	Annual % Chg. in nominal GDP due to Productivity Shock		0.34%	0.68%	1.02%	1.36%	1.69%
<i>Bottom-Up Micro Approach based on new product revenues:</i>							
10	Machine-to-Machine (MTM) Change in Private Sector Productivity	IAE, GE (2012)	0.10%	0.30%	0.50%	0.75%	1.00%
11	Machine-to-Machine (MTM) Incremental \$ Revenue	IAE, GE (2012), BEA (2012)	\$ 12.368	\$ 37.103	\$ 61.839	\$ 92.758	\$ 123.677
12	Mobile Payments Incremental Revenue	PWC (2011), IAE	\$ 5.000	\$ 7.000	\$ 10.000	\$ 11.000	\$ 13.000
13	Non-MTM Productivity Improvement due to Mobile Innovations	IAE	0.05%	0.15%	0.18%	0.21%	0.25%
14	Mobile Productivity Effects on Incremental Revenue	IAE	\$ 12.368	\$ 37.103	\$ 44.524	\$ 51.944	\$ 61.839
15	Mobile Entertainment Revenue: Net Incremental \$ Change	PWC Annual Global (2012)	\$ 22.310	\$ 23.336	\$ 24.410	\$ 25.533	\$ 26.707
16	Mobile Entertainment Revenue: Net incremental % Change	PWC Annual Global (2012)	4.60%	4.60%	4.60%	4.60%	4.60%
17	Low Estimate of Total \$ Impact on nominal GDP (Sum of above Bottom-Up Revenue figures)		\$ 52.045	\$ 104.543	\$ 140.772	\$ 181.235	\$ 225.223
18	Moderate Estimate of \$ Impact on nominal GDP (Top-Down Approach)		\$ 54.418	\$ 107.847	\$ 161.275	\$ 214.704	\$ 268.132
19	Low Estimate of % Change in nominal GDP		0.33%	0.66%	0.89%	1.14%	1.42%
20	Moderate Estimate of % Change in nominal GDP		0.34%	0.68%	1.02%	1.36%	1.69%
<b>C. Total Effects on GDP of Increased Broadband Usage due to Additional Wireless Capex</b>							
21	Low Estimate of \$ Impact on nominal GDP		\$ 81.899	\$ 135.488	\$ 172.810	\$ 214.001	\$ 259.081
22	Moderate Estimate of \$ Impact on nominal GDP		\$ 141.157	\$ 193.025	\$ 246.920	\$ 300.547	\$ 355.318
23	Low Estimate of Cumulative % Chg. in nominal GDP		0.52%	0.86%	1.09%	1.35%	1.64%
24	Moderate Estimate of Cumulative % Chg. in nominal GDP		0.89%	1.22%	1.56%	1.90%	2.24%
<b>D. Impact of Additional Wireless Capex on Total U.S. Employment (in mil. of jobs or %)</b>							
		Source	2013	2014	2015	2016	2017
25	Direct Effect on Job Creation (assumes \$110K Capex per job above \$32.5B)	Ovum (2013), IAE	26,777	20,982	22,714	23,450	28,436
26	Indirect & Induced Job Creation (via average 'job multiplier' of 3.063x)	Katz (2012)	82,027	64,274	69,580	71,836	87,110
27	Innovation-related Job Creation (via 'network multiple' of 7.28x)	Katz and Suter (2009)	194,937	152,747	165,357	170,719	207,016
28	Cumulative Jobs Created (Direct, Indirect, Induced and Innovation-related)		303,740	238,003	257,651	266,006	322,562
29	Change in Broadband Penetration Rate (as a % of U.S. population)	IAE, Analysys Mason (2012)	1%	3%	3%	2%	3%
30	Annual Jobs Created (using Sensitivity to Penetration Rate, 0.05 - 0.2x)	Katz (2012)	286,610	429,915	214,958	143,305	128,975
31	Cumulative Jobs Created (based on Growth in Penetration Rate)		286,610	716,525	931,482	1,074,788	1,203,762
32	Low Estimate of Effect on % Cumulative Growth in Employment		0.21%	0.17%	0.18%	0.19%	0.23%
33	Moderate Estimate of Effect on % Cumulative Growth in Employment		0.20%	0.50%	0.65%	0.75%	0.84%

\* - Changes in GDP and Employment are based on 2012 Q4 data: \$15,829 bil. and 143.305 mil., respectively.  
IAE = Information Age Economic's forecasts.



**Item E. Key Assumptions related to the Economic Impact Estimates**

- 1 The penetration rate is based on number of wireless broadband lines as a % of U.S. population using Analysys Mason historical data and IAE projections.
- 2 Obtained by multiplying the penetration rates in item 1 by the coefficient in Koutroumpis (2009), which measures the impact of broadband penetration on economic growth.
- 3 Based on industry historical trends, trade association projections, and IAE forecasts.
- 4 Uses a multiplier approach which estimates the direct, indirect, and induced effects of wireless capex on GDP. Average of multiplier estimates from CESP (2009) and BEA (2003).
- 5, 6 These percentage changes in GDP are based on the respective forecasts in items 2 and 4, respectively. This format is also repeated below for panels B and C.
- 7 The "top-down" change in productivity gradually increases to an additional 1.08% per year. This is the increase in productivity achieved during the internet-led expansion (1996-2004).
- 8 The productivity increase in item 7 is converted into a GDP growth estimate by using the 1891-2012 historical average of the ratio of GDP growth-to-productivity growth (1.56x).
- This "bottom-up" increase in goods-related productivity is based on GE's "internet of things" forecast and internal IAE projections. This impact is focused on an estimated 50% of the economy that is likely to take advantage of near-ubiquitous wireless broadband service rather than the entire economy.
- 10
- 11 The impact of greater productivity on GDP relies on the same 1.56x ratio used in item 8 based on 1891-2012 historical average relationship between GDP and productivity growth.
- 12 Based on PWC (2011) long-term forecast of \$13 billion in additional mobile payments due to near-ubiquitous availability of smart phones and wireless broadband in the U.S.
- 13, 14 IAE projection of increased productivity for half of the economy due to non-MTM technological innovations and converted into a GDP growth estimate using the 1.56x ratio as in items 8 and 11.
- 15, 16 PWC forecast of 4.6% CAGR through 2015 (starting from a base of \$443 bil. in 2010 and growing to \$555 bil. In 2015). Incremental revenue growth in dollar terms is reported in item 5.
- 17, 18 The sum of \$ GDP effects using the "bottom-up" approach is reported as the "Low Estimate" while the estimates based on the "top-down" method represent the "Moderate Estimate."
- 21, 22 These rows report the simple sums of the Direct Effects and Network / Innovation Effects on GDP for the Low and Moderate Estimates. For example, the Low Estimate of the \$
- 25 For jobs directly related to wireless broadband infrastructure, uses Ovum (2013) capex data to quantify the level of capex supporting each wireless carrier worker (\$110K) and then divides this number into the incremental component of IAE capex projections reported in item 3 (i.e., capex spending above the recent level of \$32.5 billion).
- 26 Uses an average of "Type II" jobs multipliers (3.063x) to estimate the number of indirect and induced jobs created by item 25's direct job growth.
- 27 To capture the effect of innovation- and network-related job growth, the higher end jobs multiplier estimated by Katz and Suter (2009) is used (7.28x the direct job growth).
- 29 Changes in wireless broadband penetration rates based on data from Analysys Mason (2012) and IAE projections, as first noted in item 1.
- 30 Uses lower end of range of job growth's sensitivity to penetration rates (0.20x) and then decreases this sensitivity over time to 0.05x as the penetration rate rises to near ubiquity in 2017.
- 32, 33 Displays the cumulative growth in jobs over the forecast period using the jobs multiplier method (the Low Estimate) and the penetration rate sensitivity approach (the Moderate Estimate).



PCIA – The Wireless Infrastructure Association is the trade association representing the companies that make up the wireless telecommunications infrastructure industry. Our members include the carriers, infrastructure providers and professional services firms that own and manage more than 130,000 telecommunications facilities throughout the world.

Visit us at [www.pcia.com](http://www.pcia.com)

*For more information:*

**Government Affairs Department**  
[advocacy@pcia.com](mailto:advocacy@pcia.com)